Performance Based Evaluation of RC Frame Buildings at Regularity Limit

SYNOPSIS OF THE THESIS

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Introduction

Earthquake engineering has developed as a branch of engineering concerned with the estimation of earthquake impacts, since last few decades. It has become an interdisciplinary subject involving seismologists, structural engineer, geotechnical engineers, architects, urban planners, information technologists and social scientists. The devastating effect of an earthquake can have major consequences on infrastructures and lifelines. The earthquake engineering community has been reassessing its procedures, in the past few years, due to such earthquakes which have caused extensive damage, loss of life and property. These procedures mainly consider assessment of seismic force demands on the structure and then developing design procedures for the structure to withstand the applied actions. The seismic design in most of the structures is based mainly on elastic force. The nonlinear response of structure is not incorporated in design process but its effect is integrated by using a reduction factor called Response Reduction factor (R). There are differences in the way the response reduction factor (R) is specified in different codes for different kinds of structural systems.

The concept of response reduction factor is to reduce the seismic force and incorporate nonlinearity with the help of over strength, damping, redundancy and ductility. Ductile detailing is done in structure to increase the ductility and to reduce the amount of damage compared to non-ductile detailed structure. High ductile designed frame will attract more damage compared to structure designed for lower ductility, due to large yield excursion. The design seismic forces are reduced drastically by using higher values of R and incorporating higher ductility. Response reduction factor (R) is defined differently in different countries for different types of structural systems. In Indian seismic code, IS1893:2002, value of R for reinforced concrete structure is specified based on, ordinary moment resisting frame (OMRF) and special moment resisting frame (SMRF), and in the latest proposed draft one additional R value incorporated for reinforced concrete structure based on Intermediate moment resisting frame (IMRF). The value of R varies from 3-5 in IS code as per type of resisting frame. IS code defines R as Response Reduction factor, ASCE defines as Response modification coefficient and EC defines as Behavior factor. IS-1893 provides R factor for reinforced concrete structures with three ductility classes; OMRF, IMRF and SMRF with R value as 3, 4, and 5 respectively. EC8 provides behavior factor for regular RC structures with two ductility classes: Medium ductility (DCM) and High ductility (DCH). Behavior

factor includes over strength factor with a value of 1.3 for multistory multibay frame. Euro code also mentions a reduction in behavior factor for irregular buildings. ASCE07 provides appropriate response modification coefficient (R), system over strength factor and the deflection amplification factor (Cd), these factors shall be used in determining the base shear, element design forces and design story drift, respectively. Response reduction factor consists of majorly four parameters; strength, redundancy, ductility and damping.

$$R = R_S R_R R_\mu R_\xi$$

Where $R_S, R_R, R_\mu, and R_\xi$, represents overstrength, redundancy, ductility and damping factors, respectively.

Objectives of Research

Following are the objectives of proposed research study.

1. To evaluate the value of "R" (response reduction factor) for RC building at regularity limit.
2. To check the behavior of stepped building.
3. To calculate the exact value of regularity limit (A/L ratio) for the obtained response reduction factor.

Review of Literature and Development in the subject

Brahmavrathan and Arunkumar (2016), had focused on the evaluation of the actual value of R for stepped buildings. Three dimensional models with varying number of storeys in each step were created, consisting of both ordinary RC moment resisting frame and special RC moment resisting frame having 3, 6 and 9 storeys. Nonlinear static pushover analysis is carried out on the analytical models using finite element analysis software SAP 2000. The R factor components such as ductility and over strength factors were computed from the results obtained from the nonlinear static pushover analysis and finally the response reduction factor is calculated for all the models.

Chintanapakdee and Chopra (2004), had compared the seismic demands for vertically irregular and regular frames determined by rigorous nonlinear response history analysis (RHA), due to an ensemble of 20 ground motions. Forty-eight irregular frames, all 12-story high with strong

columns and weak beams, were designed with three types of irregularities such as stiffness, strength, and combined stiffness and strength introduced in eight different locations along the height using two modification factors.

Goud and Kumar (2014), had done study to compute the value of R, component wise of a G+4 storey building designed for all seismic zones, considering ductile and non-ductile design provisions and the same is compared with the response reduction factor which is provided by Indian standard code to check the safety of the structures. The value of R provided is computed from the obtained pushover curves for all the structures in all seismic zones.

Inel and Ozmen (2006), studied the possible differences in the results of pushover analysis due to default and user-defined nonlinear component properties. Four and seven-story buildings are considered to represent low and medium- rise buildings for this study. Plastic hinge length and transverse reinforcement spacing are assumed to be effective parameters in the user-defined hinge properties. Observations show that plastic hinge length and transverse reinforcement spacing have no influence on the base shear capacity, while these parameters have considerable effects on the displacement capacity of the frames. Comparisons point out that an increase in the amount of transverse reinforcement improves the displacement capacity.

Kwawinker and Nassar (1992), had proposed a seismic design procedure that accounts explicitly for ductility and cumulative damage demands and capacities. Emphasis is placed on strength, ductility, and energy demands. Results are presented for demands imposed by rock and stiff soil ground motions on single and multi-degree of freedom systems. The objective of the paper is to demonstrate that ductility and cumulative damage considerations can and should be incorporated explicitly in the design process.

Miranda et.al (1994), has worked in calculating strength reduction factors, results of various investigations carried out in last 30 years are reviewed and presented the results in common format.

Mondal et.al (2013), had evaluated response reduction factor by doing the performance based evaluation, two performance limits were plotted i.e one for structural level another for member

level and the value of response reduction factor was calculated for regular ductile RC frame buildings.

Saatcioglu et.al (1992), had worked on analytical model to construct a stress -strain relationship for confined concrete. The model consists of a parabolic ascending branch, followed by a linear descending segment. It is based on calculation of lateral confinement pressure generated by circular and rectilinear reinforcement, and the resulting improvements in strength and ductility of confined concrete

Whitterkar et.al (1999), had evaluated value of response modification factor by experimentally and analytically. In this study, response reduction factor has been split up in three parameters, strength, ductility and redundancy. So the value of all these factors is calculated and finally value of response modification factor is determined.

Zeris et.al, had carried out analytical investigations on the performance evaluation of typical existing irregular reinforced concrete frames have focused on the evaluation of the over strength, the global ductility capacity and the available behavior factor q (Response reduction factor) of such buildings, designed according to the previous generations of design codes in Greece.

Scope of present work

In the proposed study, value of response reduction factor will be calculated at regulairity limit and compared with the value which is given in IS 1893 (part1): 2002 by using "OpenSees" software.

Methodology

Collection of literature review of research work will be carried out. The methodology of proposed work includes, software based analysis of regular building at regularity limit permitted in the Indian standard code. Modelling of RC building can be carried out, R values are estimated on the basis of nonlinear static pushover analyses and two different performance limit can be plotted based on structural level and member level analysis. Value of response reduction factor can be computed and compared with the values provided in Indian standard code.

Expected Outcomes

1. Value of Response reduction factor at irregularity limit might vary compared to value provided in the code.
2. Stepped building might have stable behavior.
3. A/L ratio provided by the code might vary.

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